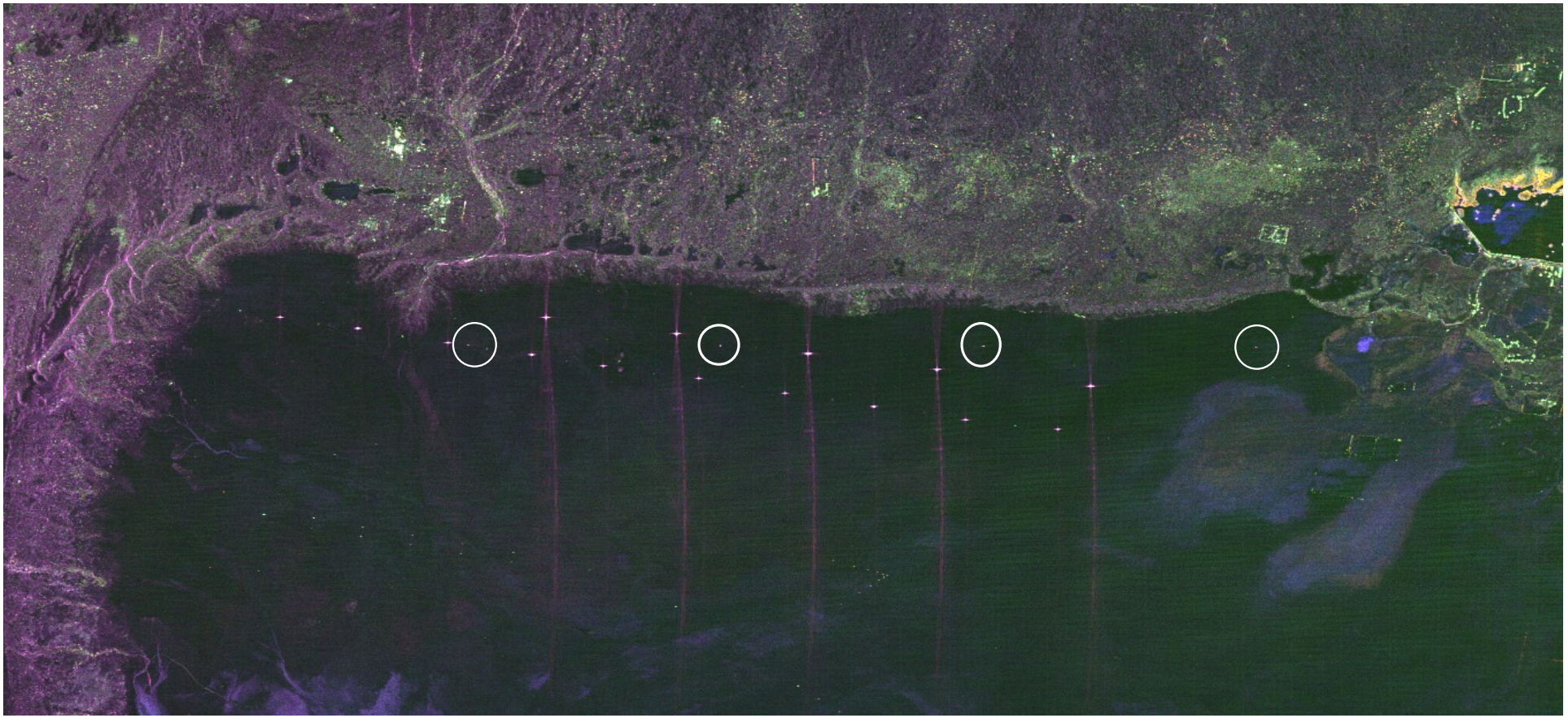
Jet Propulsion Laboratory
California Institute of Technology

The Rosamond Corner Reflector Array for SAR Calibration; Past, Present, Future

Ronald J. Muellerschoen
Radar Science and Engineering
Jet Propulsion Laboratory, California Institute of Technology

Rosamond Corner Reflector Array

UAVSAR 80 MHz Polarmetric L-band Image Sept, 2017



5 4.8 meter corners – all 350 headings

23 2.4 meter corners – 10 with 350 heading, 13 with 170 heading

4 0.7 meter corners – all 350 headings

Rosamond Corner Reflector Array

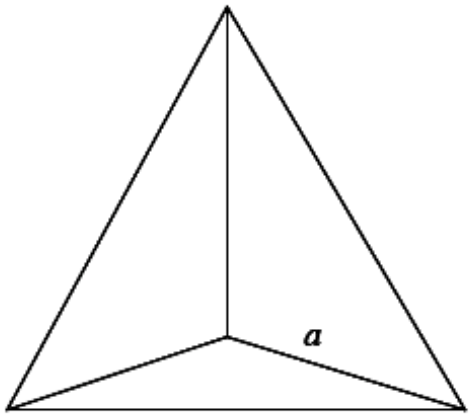
3 sizes designed for 3 frequency bands

- **2.4 meter trihedral for L-band**
  - **L-Band: λ/10 = 2.4 cm (0.9”)**
  - **CR hole size 0.24 cm (0.09375”)**
    - **10x smaller than needed**
- **4.8 meter trihedral for P-band**
  - **CR hole size 1.3 cm (0.5”)**
    - **Still small enough for L-band**
  - **48% open area for lighter weight**
- **0.7 meter trihedral for Ka-band**
  - **Ka-band: λ/10 ~ 0.08 mm**
  - **need solid structure**

Rosamond Corner Reflector Array

3 trihedral sizes designed for 3 frequency bands

Target Band (λ in cm)	Side Length (m)	Mesh Hole Size (cm)	Max RCS @ band (dBsm)	Max RCS @ L band (dBsm)
Ka (0.84)	0.700	0 (solid reflector)	46.30	17.25
L (23.8)	2.438	0.24 (<< 24/10)	34.16	34.16
P (69.7)	4.800	1.30 (< 24/10 also)	36.60	45.92



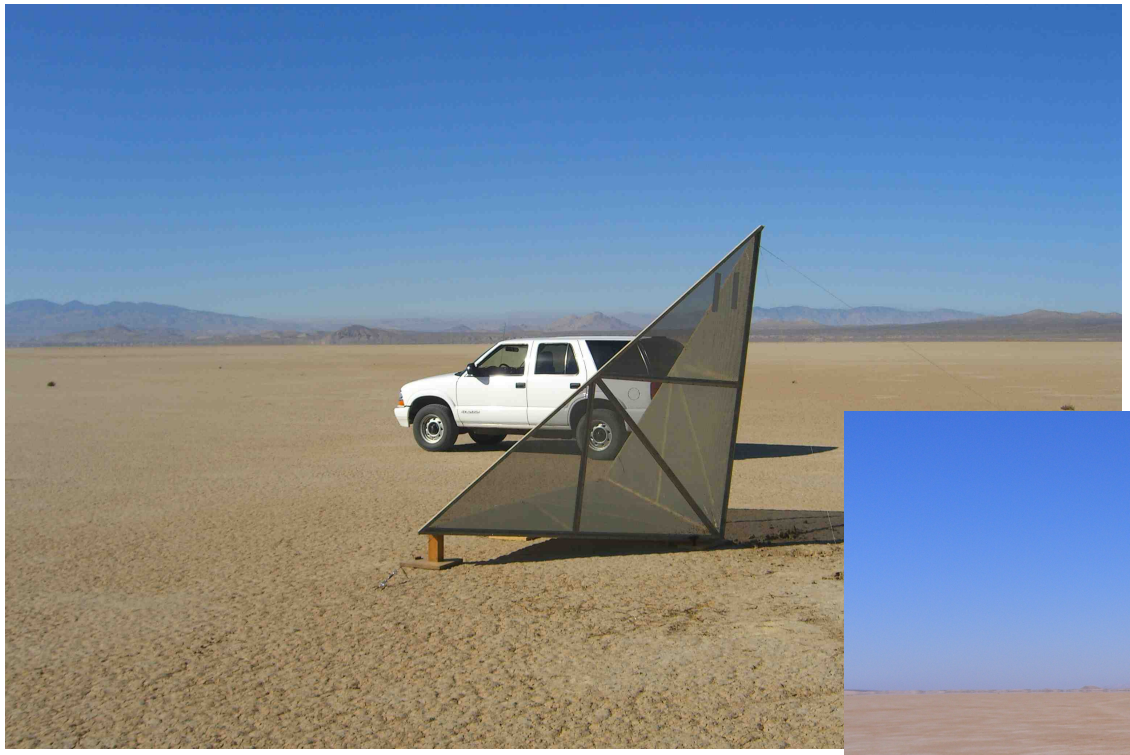
$$\sigma_{tri,max} \leq \frac{4\pi a^4}{3\lambda^2}$$

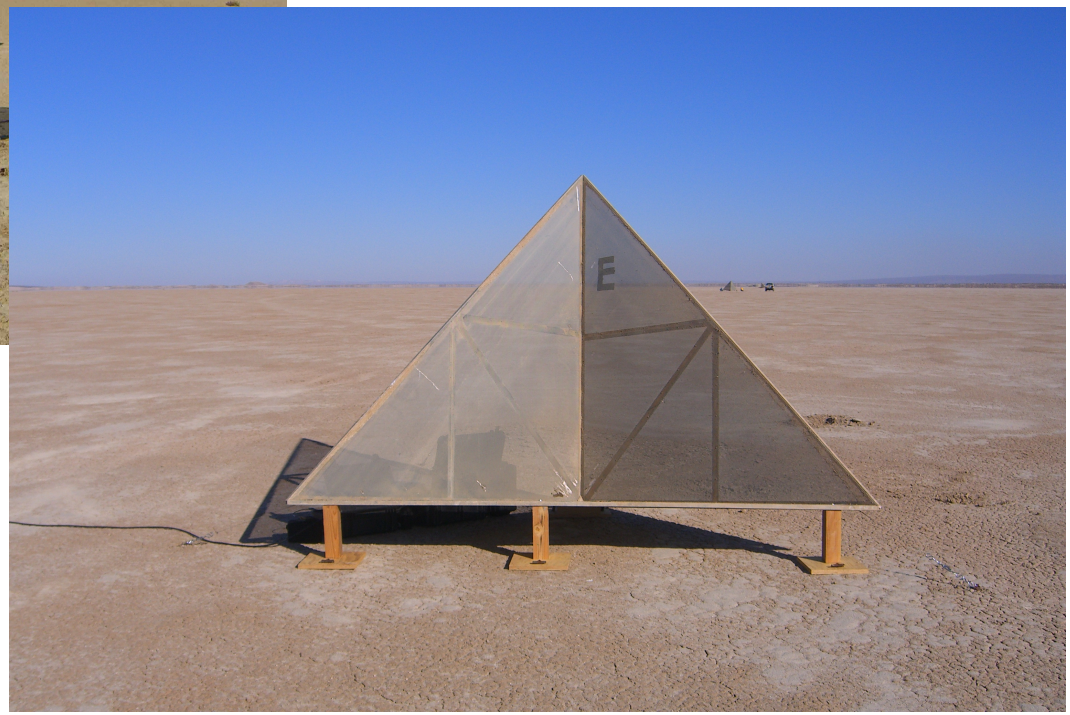
4.8 meter Trihedral for P-band

Installed in May-June, 2012

2.4 meter Trihedral for L-band

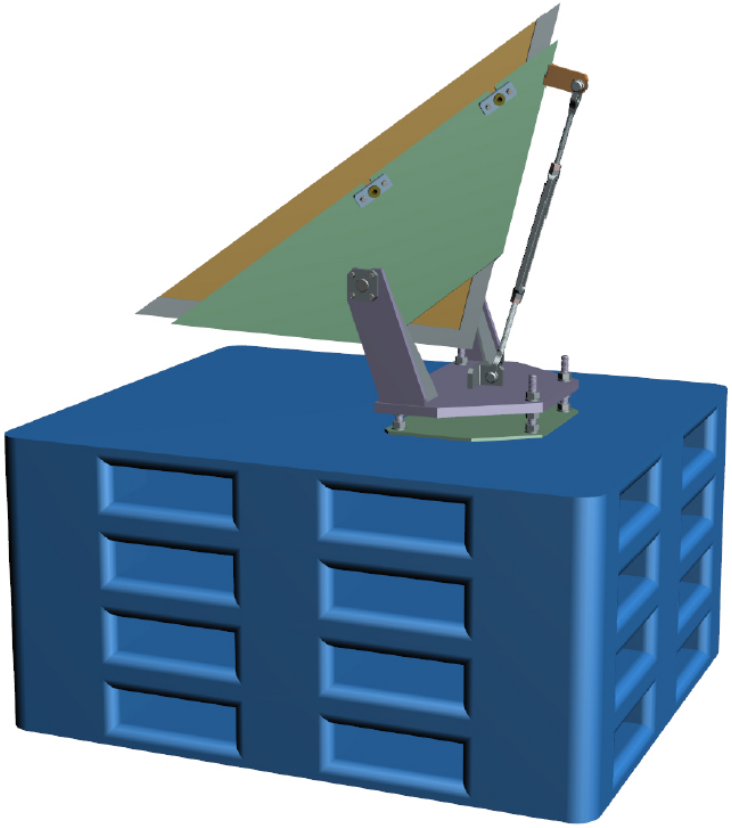
10 in 350 degree heading, 13 in 170 degree heading





0.7 meter Trihedral for Ka-band

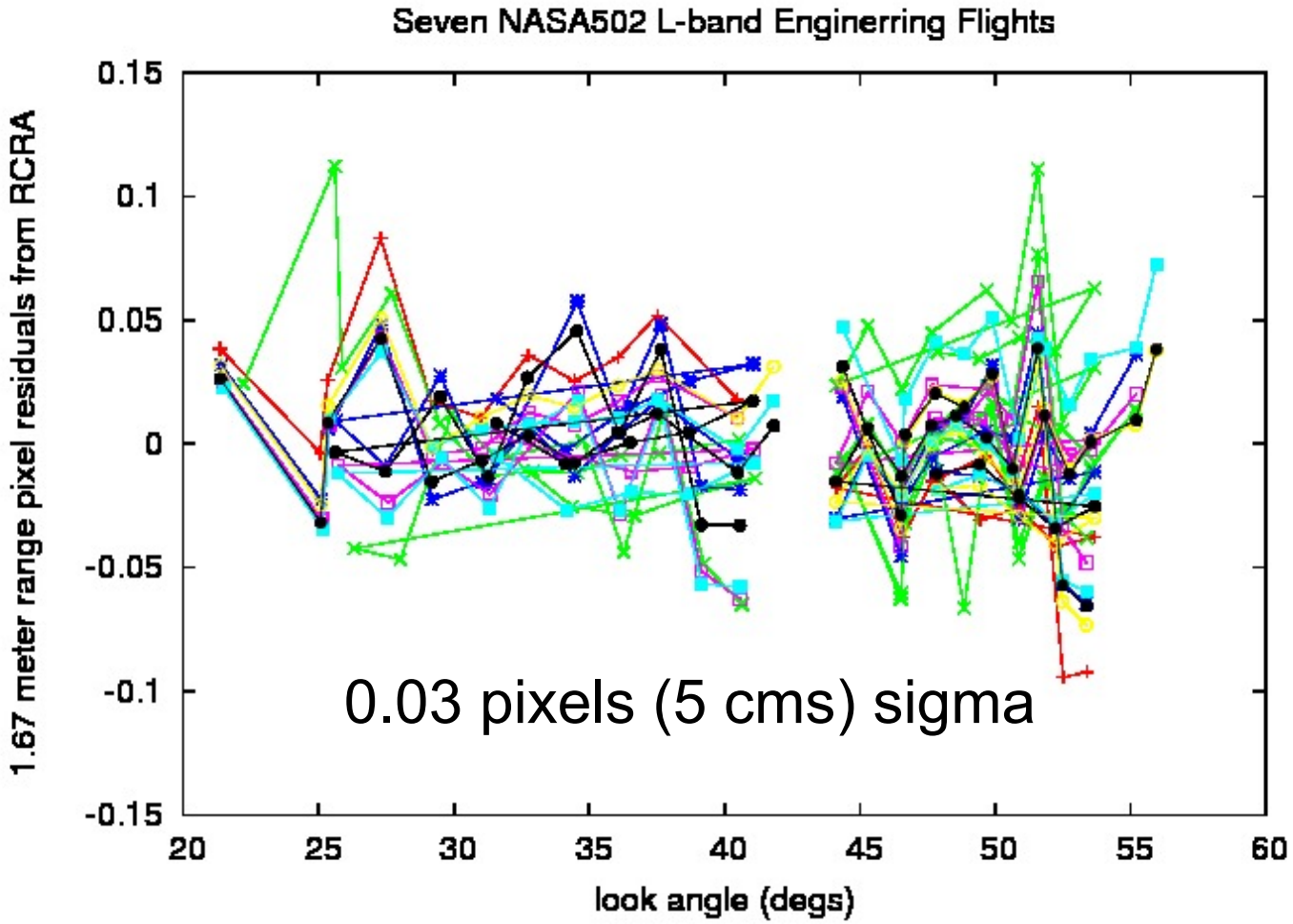
4 installed in December 2015



L-Band RCRA 2017 Range Residuals

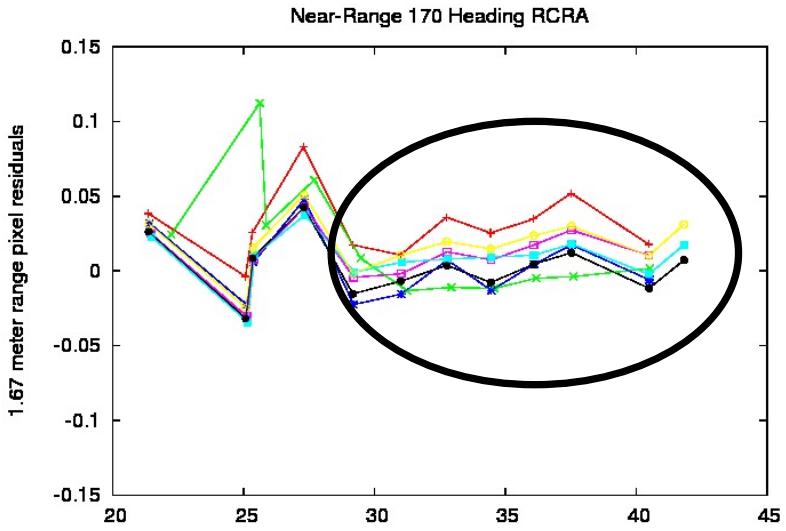
With Once-Per-Flight Trop Estimate, and no changes to common delay.

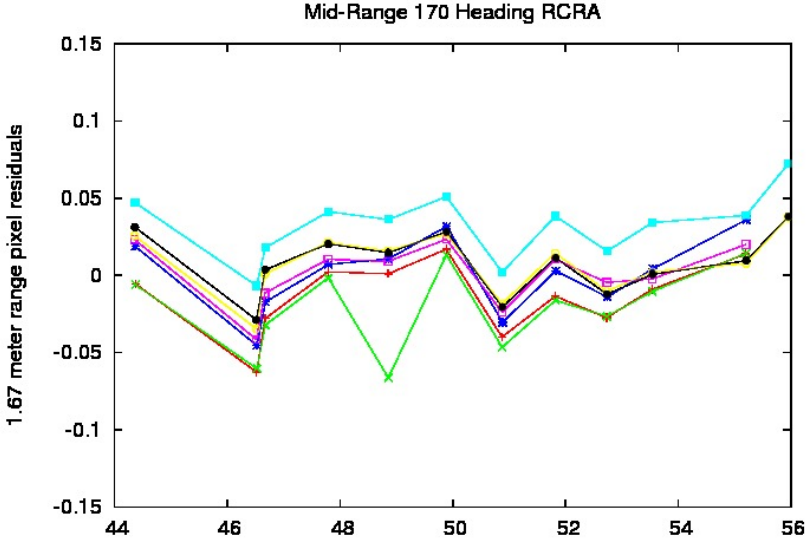
Yaw variation from 2 to 15 degrees.

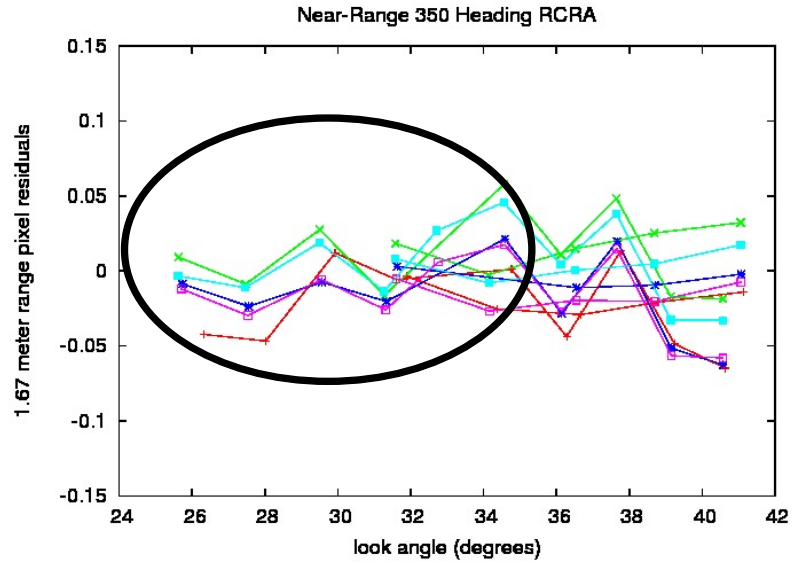


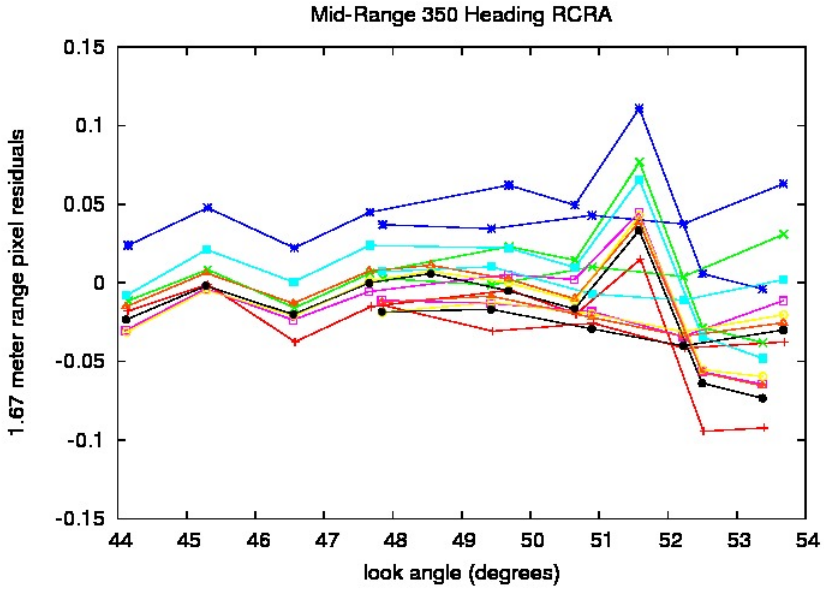
Not all CRs Have Same Location Accuracy

Low Lake corners not as well determined as High Lake corners









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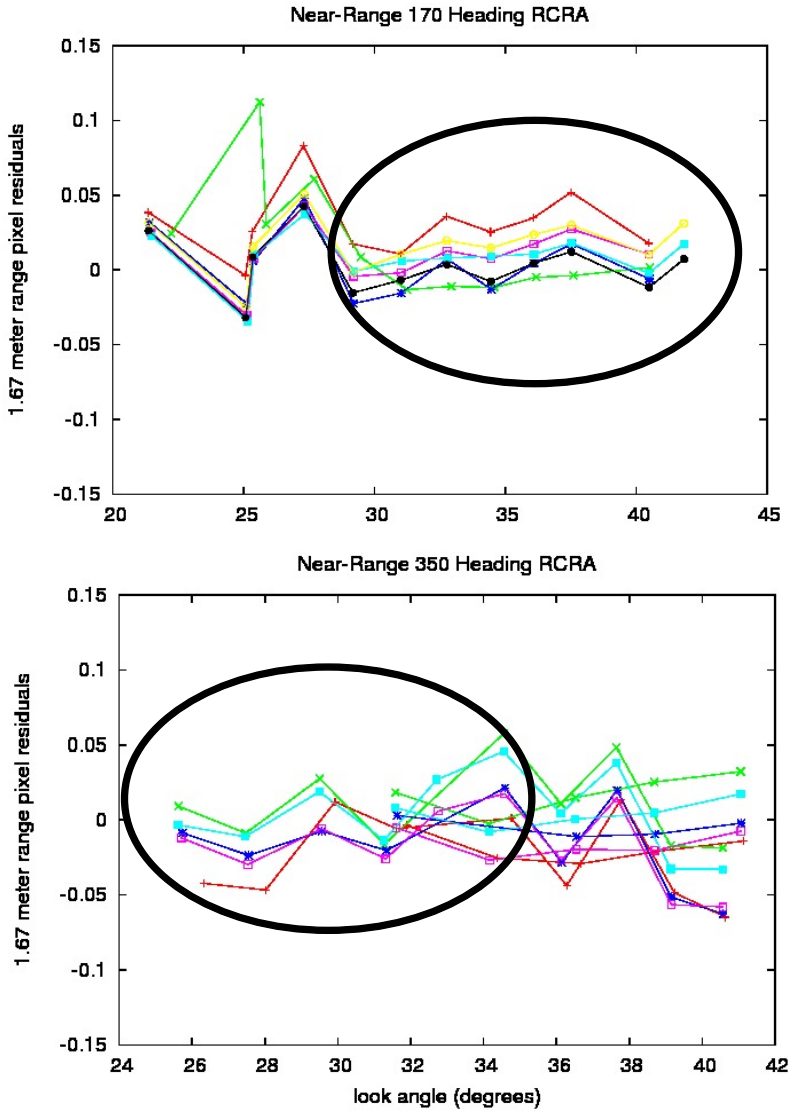


170 Heading Corners #s >= 4
sigma: 2.5 cms

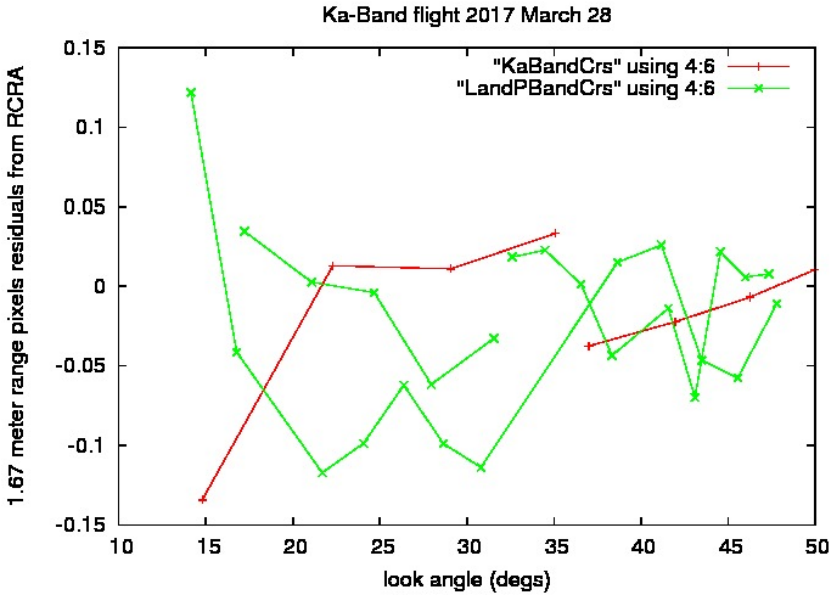
350 Heading Corners #s >= 16
sigma: 3.6 cms

350 Heading Corners #s >= 23
sigma: 2.8 cms
(these are the 4.8 meter CRs)

Resurvey CR #s in Dec 2017
170s: 00, 01, 02, 03, and 10
350s: 13,14,15

Ka-Band RCRA 2017 Range Residuals

Yaw variation from 2 to 15 degrees.

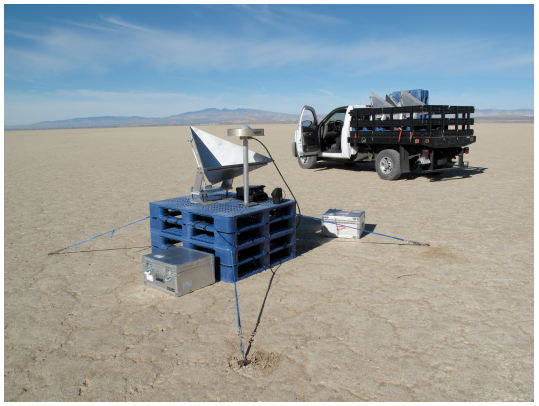


KaBandCrs:
0.024 pixels (4 cms) sigma
(excluding low angle outlier)

Difference from 15dec02 survey to 16sep28 survey (cms)

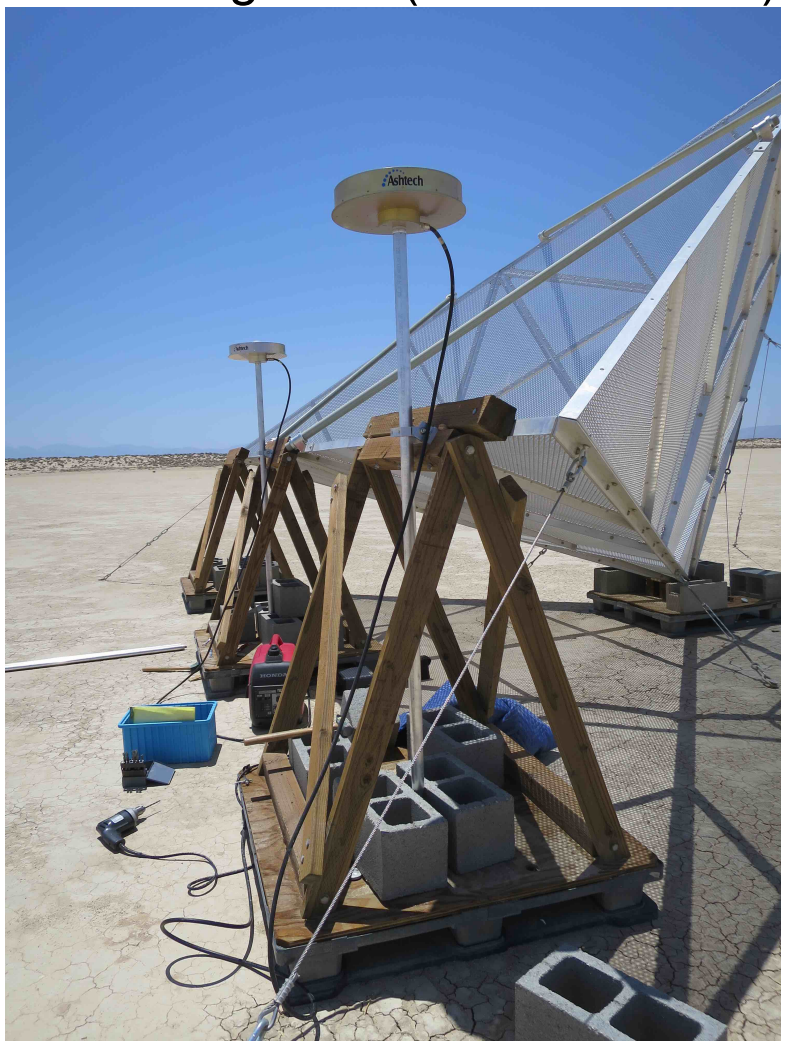
CR #	East	North	Vertical
28	0.8	-0.1	-0.9
31	1.8	0.1	-2.0
34	1.0	0.2	-1.7
37	-0.5	-1.0	-0.8

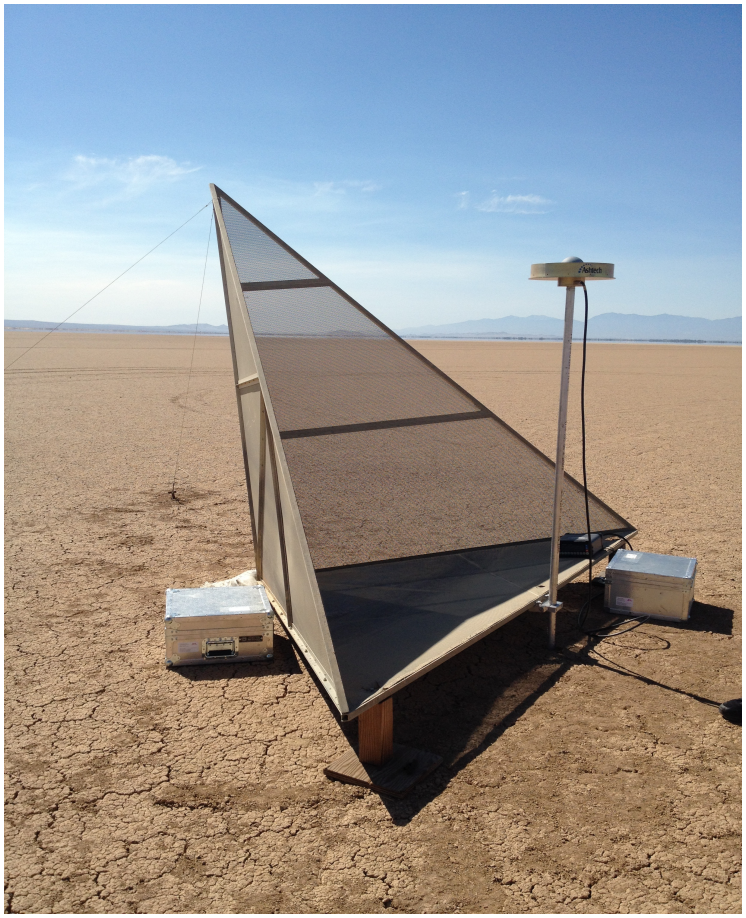
Uses single-freq. double-difference ambiguity resolution with Lambda/Z-transform



Measuring Corner Reflectors

Using GPS (w/base station) and Laser for Precise Location of Center

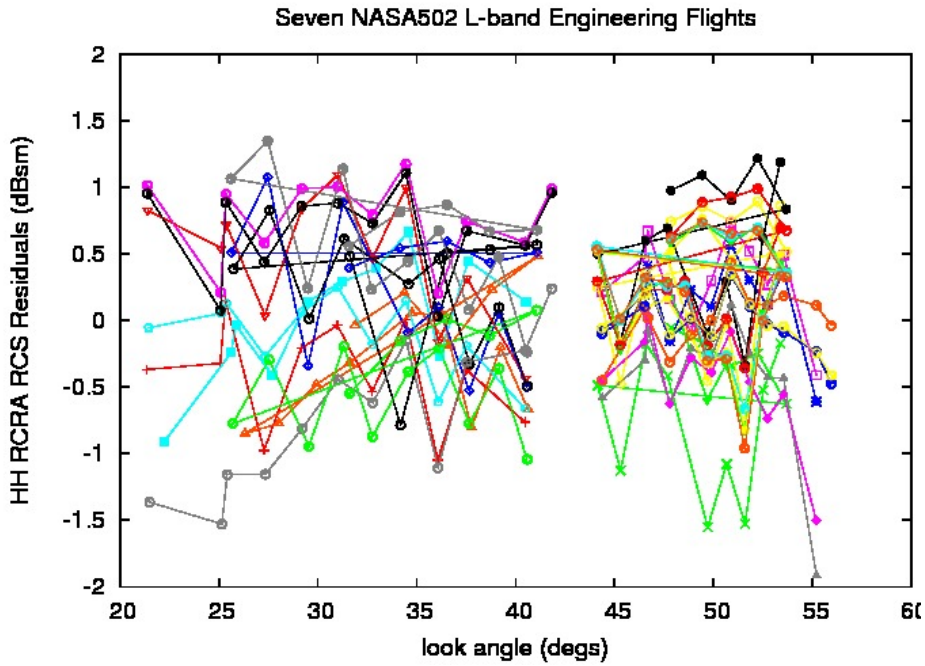


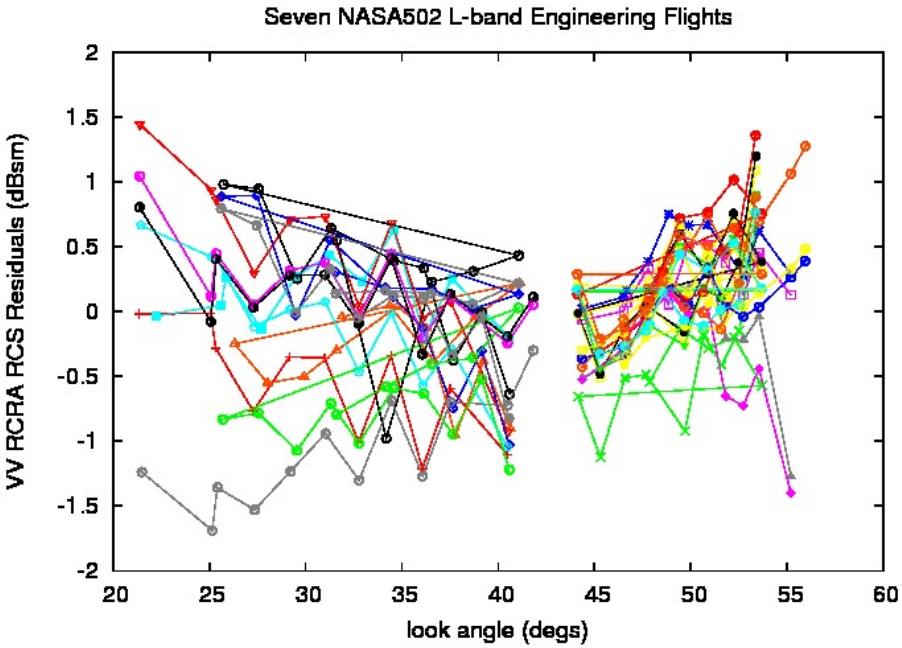


Attach Laser Range Finder and Digital Tilt Meter to top of GPS pole To Measure Apex

Radiometrics from L-band

Uses 2.4 meter and 4.8 meter CRs

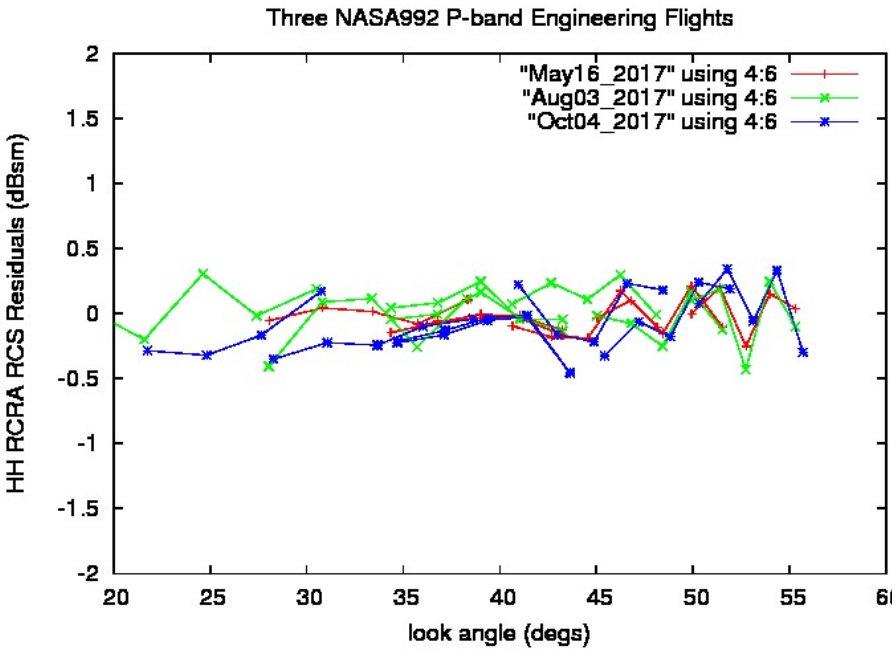


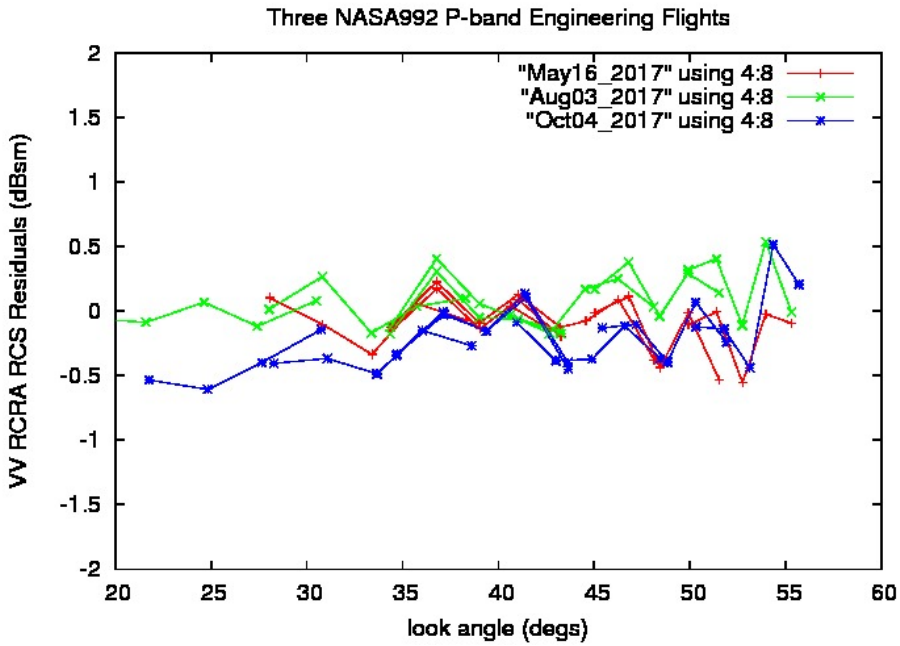


RCS sigma for HH: 0.57 dBsm
RCS sigma for VV: 0.52 dBsm

Radiometrics from P-band

Uses only 4.8 meter CRs and Noise Diode Calibration



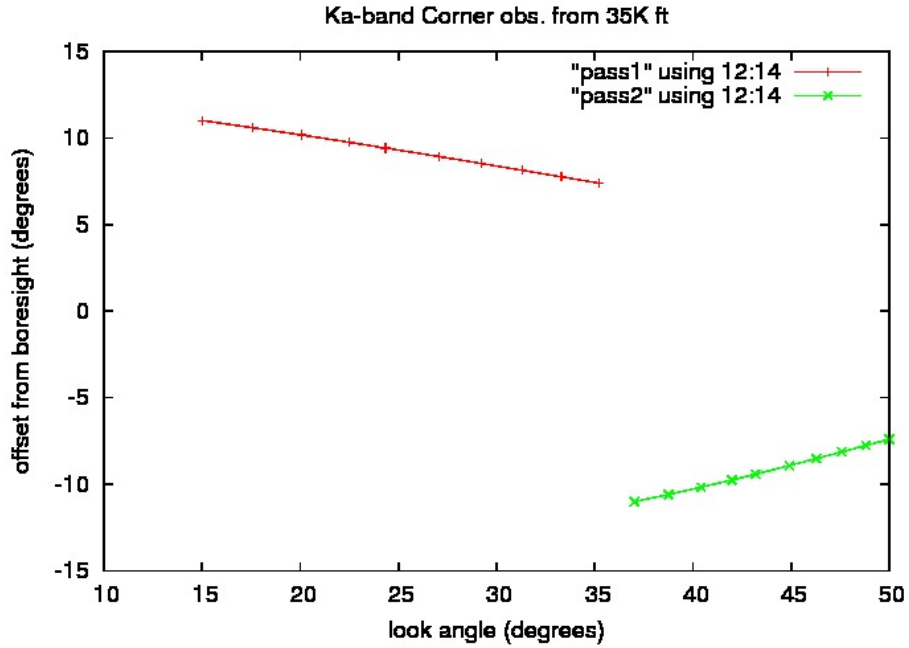


RCS sigma for HH: 0.18 dBsm
RCS sigma for VV: 0.24 dBsm

*This is with RCS2017 Antenna Pattern and not the AirMoss Antenna Pattern

Six Additional 0.7 Meter Reflectors in 2018

Currently only #28, #31, #34, #37 Deployed



CR #	Latitude	Longitude	Elevation
28	34.7989	-118.0948	12.1
29	34.7997	-118.0895	13.7
30	34.8005	-118.0843	15.3
31	34.8012	-118.0791	17.0
32	34.8020	-118.0738	18.8
33	34.8029	-118.0675	21.0
34	34.8035	-118.0634	22.5
35	34.8043	-118.0581	24.5
36	34.8050	-118.0529	26.6
37	34.8058	-118.0476	28.7

Additional of Two PARCs in 2018

Polarimetric Active Radar Calibrators

PARCs will provide UAVSAR with a
53.4 degree look for Rosamd_17017
26.4 degree look for Rosamd_35012

Obtaining Locations of RCRA Locations

https://uavsar.jpl.nasa.gov/cgi-bin/calibration.pl

- Coordinates are available back to 1-jan-2000
- Rains in winter 2005-2006 flooded the Lake Bed
  - 25 % of the CRs were washed away
  - 50 % additionally required repositioning
- Periodic maintenance requires repositioning due to erosion
  - CR#18 was washed away this year but now available
  - CR#10 is TBD
- Revisit Lake Bed December 2017 to resurvey low # CRs and #10
- Lake Bed moving at 2.4 cms/year azimuth direction of 283 degrees
- Web Interface will account for repositioning and continental drift
  - Coordinates expressed in WGS-84 ellipsoid
  - Uses IGS14 Reference Frame

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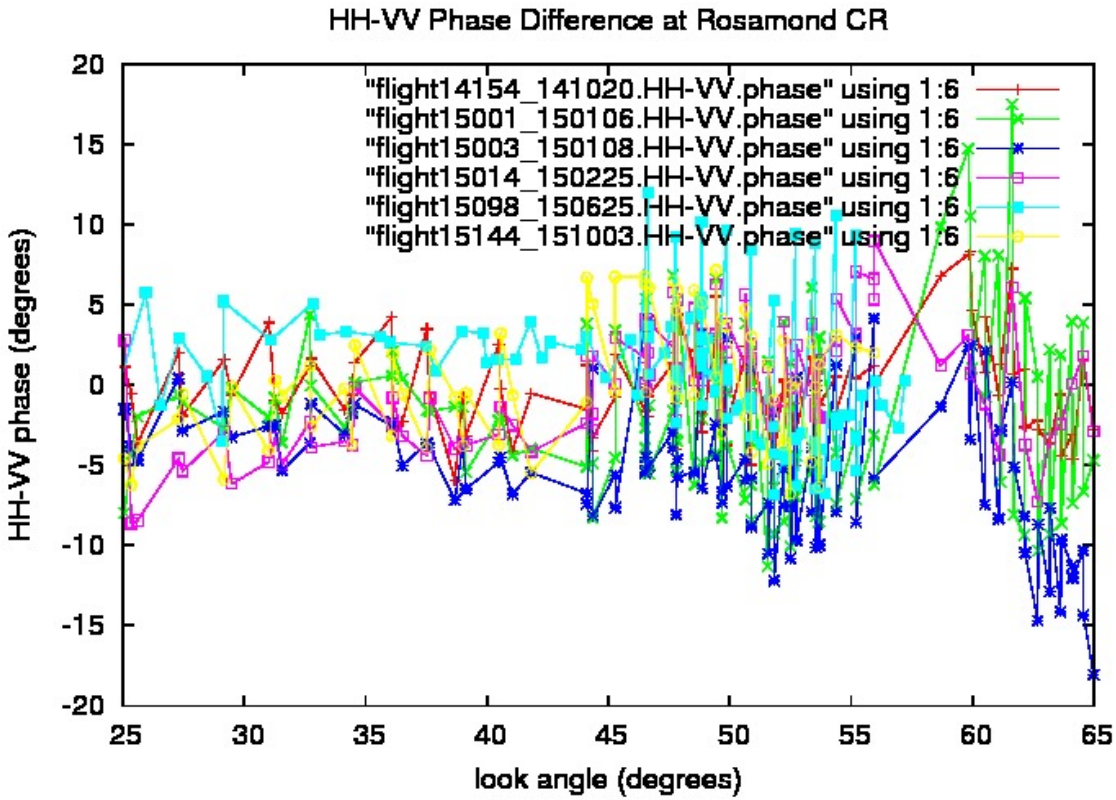
L-band HH-VV Phase Difference At CRs

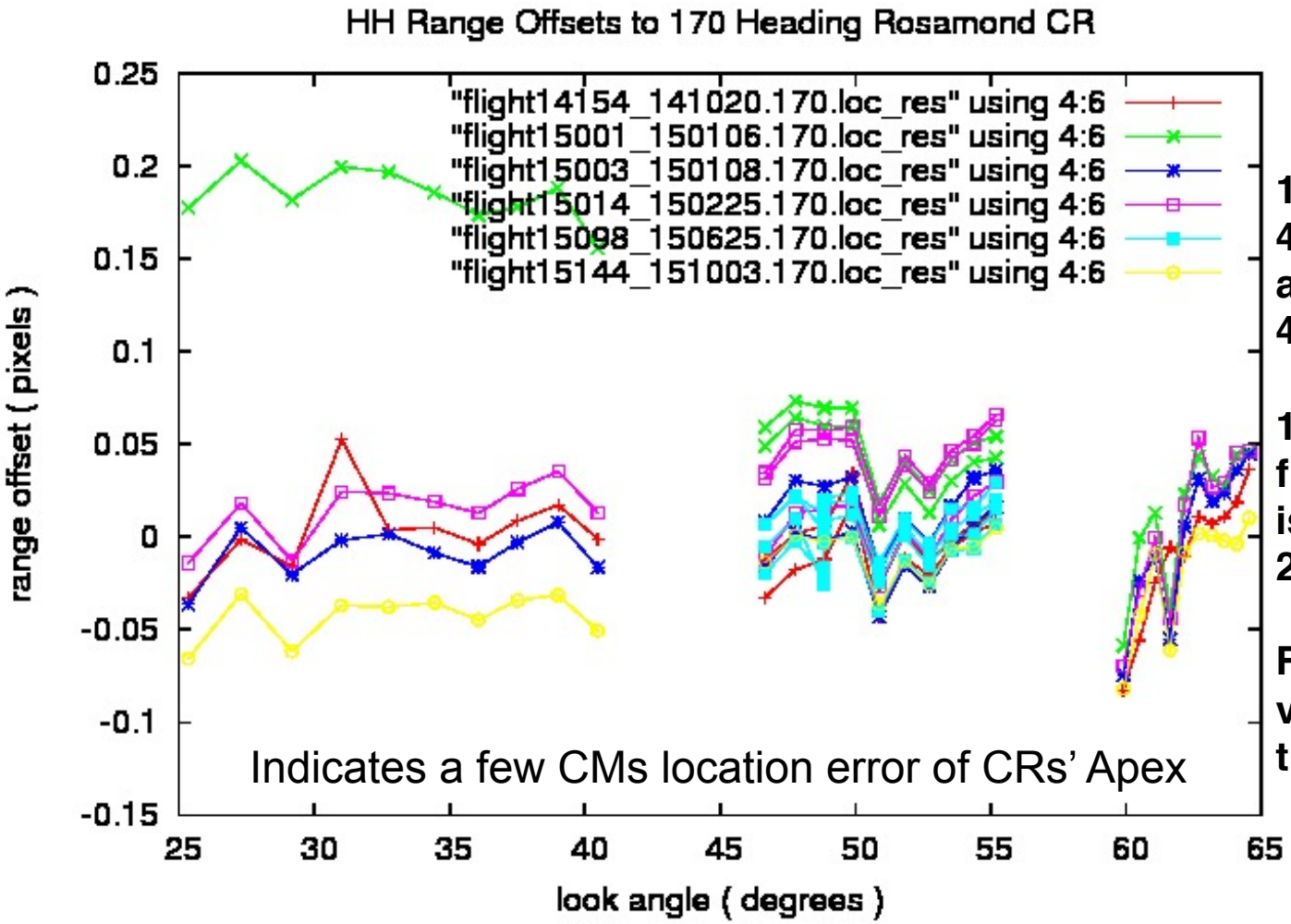
Oct 2014 to Oct 2015



with *a priori* model of -0.3 degrees/look_angle(degree)
L-band RMS: 4.8 degrees

UAVSAR L-band Range Offsets to CRs

170 degree Heading, Oct 2014 to Oct 2015



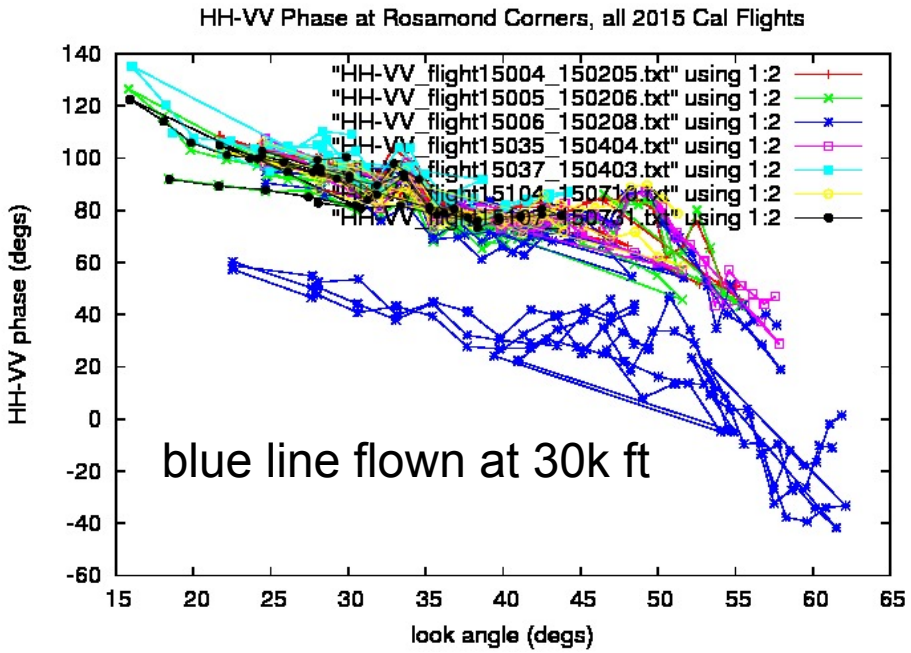
1-sigma scatter from 46 to 56 degrees look angle is 0.026 pixels or 4.3 CMS

1-sigma scatter from flight15098 on 15jun25 is 0.015 pixels or 2.5 CMS

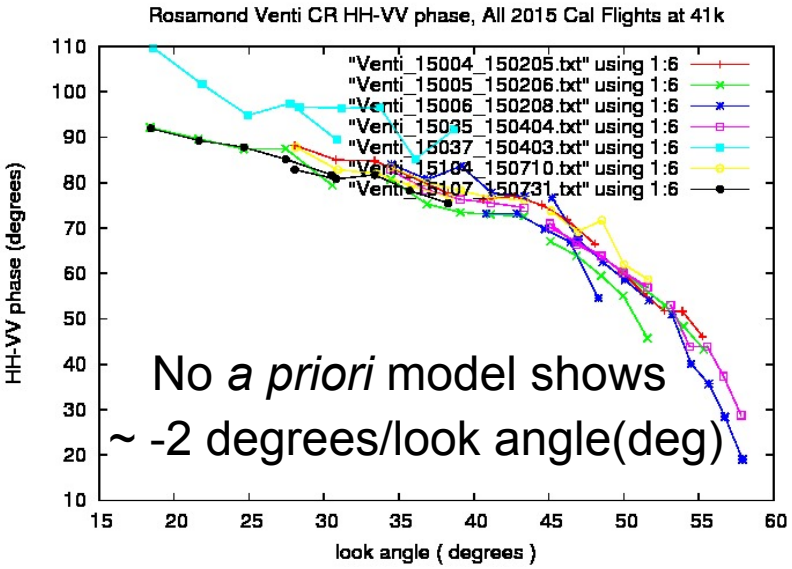
Flight-to-flight variation partly due to troposphere.

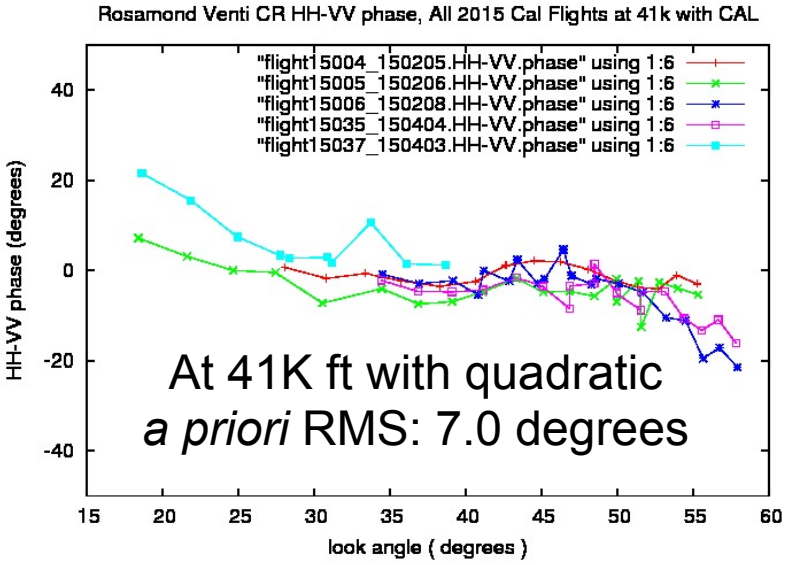
P-band HH-VV Phase Difference At CRs

HH-VV Phase from 4.8 M CR, 2015



Dynamic air pressure affects radiometrics due to the wing movement.





Chapin, E.; Chau, A.; Chen, J.; Heavey, B.; Hensley, S.; Lou, Y.; Machuzak, R.; Moghaddam, M., "AirMOSS: An Airborne P-band SAR to measure root-zone soil moisture," in *Radar Conference (RADAR), 2012 IEEE* , vol., no., pp.0693-0698, 7-11 May 2012